Computer

THE IMPACT OF HPP-STYLE AI WORK ON SCIENTIFIC METHODOLOGY

We may distinguish between two rather different forms that an interest in scientific methodology might take:

1. The attempt to provide an accurate, systematic, and illuminating characterization of the scientific practice of an historically given group of scientists, past or present.

2. The attempt to transform and improve scientific practice in a given area, prompted by the availability of powerful new tools, and guided by the intuitive sense of methodological rightness of scientists practicing in the given area.

The first of these approaches to the study of methodology is descriptive, while the second is primarily normative (though the new, improved methods surely are to be described, with both completeness and precision).

While each of these approaches is reflected to some degree in the AI work done at SUMEX-AIM, it seems to me that the second one is preponderant, no less interesting philosophically than the first, and potentially much more significant from a practical point of view. Some serious description of existing scientific practice is attempted, but this is not pursued beyond the level accessible to introspection, and tends to be used merely as a starting point for improvements. Even in situations where the initial intent is only to make existing methods more fully explicit, the HPP emphasis on high performance is likely to lead to transformed methods designed to take advantage of the special abilities of the computer.

In the instances of the second approach that concern us, the "powerful new tools" are of course the computer and associated AI programming techniques. New tools generally call for changed methods; the correct approach to a given problem for an investigator armed with a slide rule and two graduate assistants will in general be quite different from the right approach to the same problem for an investigator equipped with a PDP-10 and a research staff of 20. In effect, one engaged in the effort to develop appropriate new methods must somehow elicit from his informed "methodological conscience" or "scientific intuition" the best way to proceed in the new situation. This is no easy task, however, since the intellectual component here referred to as "methodological conscience" seems to be more of a tester than a generator of new methods. Also, the test itself is not a simple a priori one, but involves a strong empirical component. One plausible approach to the generation problem is to view possible new methods as modified versions of existing methods.

Pursued at the lowest level, such methodological enterprises are hardly distinguishable from the main body of scientific research which, with regularity if not routine, results in the development of new methods. But the HPP methodologist typically is looking for the general in the particular; he is especially interested in developing methods whose ranges of applicability extend well beyond the contexts of their development.

So our methodologist is faced with his own practical problem of induction.
If he succeeds in finding methods with demonstrable applicability over a
very wide range of subject matters, then he will have contributed not

just to (say) chemical methodology, but to the methodology (and perhaps
even the logic) of science.

Consider now, for example, the thesis that "scientific discovery
is heuristic search," in the context of work on DENDRAL and
Meta-DENDRAL. What is the status of this thesis in the light of the
foregoing discussion? The thesis is not the descriptive conclusion of a
careful empirical investigation of human discovery processes, since no
such investigation has been undertaken by the Heuristic Programming
Group. Nor is it merely the assertion of a possibility, the result of a
"sufficiency analysis" in Newell's sense. Rather, it is (or at least
aspires to be) a normative methodological prescription. Whether it is
regarded prior to the DENDRAL investigations as a preliminary working
hypothesis, or afterwards as a conclusion supported by those
investigations, the thesis asserts that, in view of the information
processing capabilities that are now becoming available, scientific
discovery OUGHT to be a matter of (computer-aided) heuristic search.
[The 'ought' occurring here is that of rationality, not morality.]

It must, of course, be considered what qualifications (if any)
should be made to this thesis -- or equivalently, how broad an
application of the thesis is justified by the experience with DENDRAL
and Meta-DENDRAL. It must also be considered whether more specific
versions of the thesis can be supported -- versions that relate certain
kinds of discovery problem with specific forms or organizations of
heuristic search. And it must be asked whether a reasonable range of
alternatives to the versions being defended have been conceived,
developed, and allowed to compete fairly. But these inductive issues do
not change the basic nature of the thesis as a prescription of normative
methodology. To the extent that investigators generally become
convinced that this prescription is correct and widely applicable on a
practical basis, scientific discovery will in fact become a matter of
(computer-aided) heuristic search.

I think that similar analyses would be appropriate for most
(though perhaps not quite all) of the methodological theses that AI work
at SUMEX-AIM might be found to support. If this is so, then the main
impact of HPP-style AI work on scientific methodology is the development
of new, improved methods that are precisely formulated, with some
improved understanding of current methods being produced as a
by-product. At the minimum, the new methods may be of quite limited
applicability, and not clearly better than many plausible but untried
alternatives. At the maximum, they may be contributions to the logic of
science. Needless to say, this impact of AI on methodology is in its
earliest stages, being at present far more potential than actual.